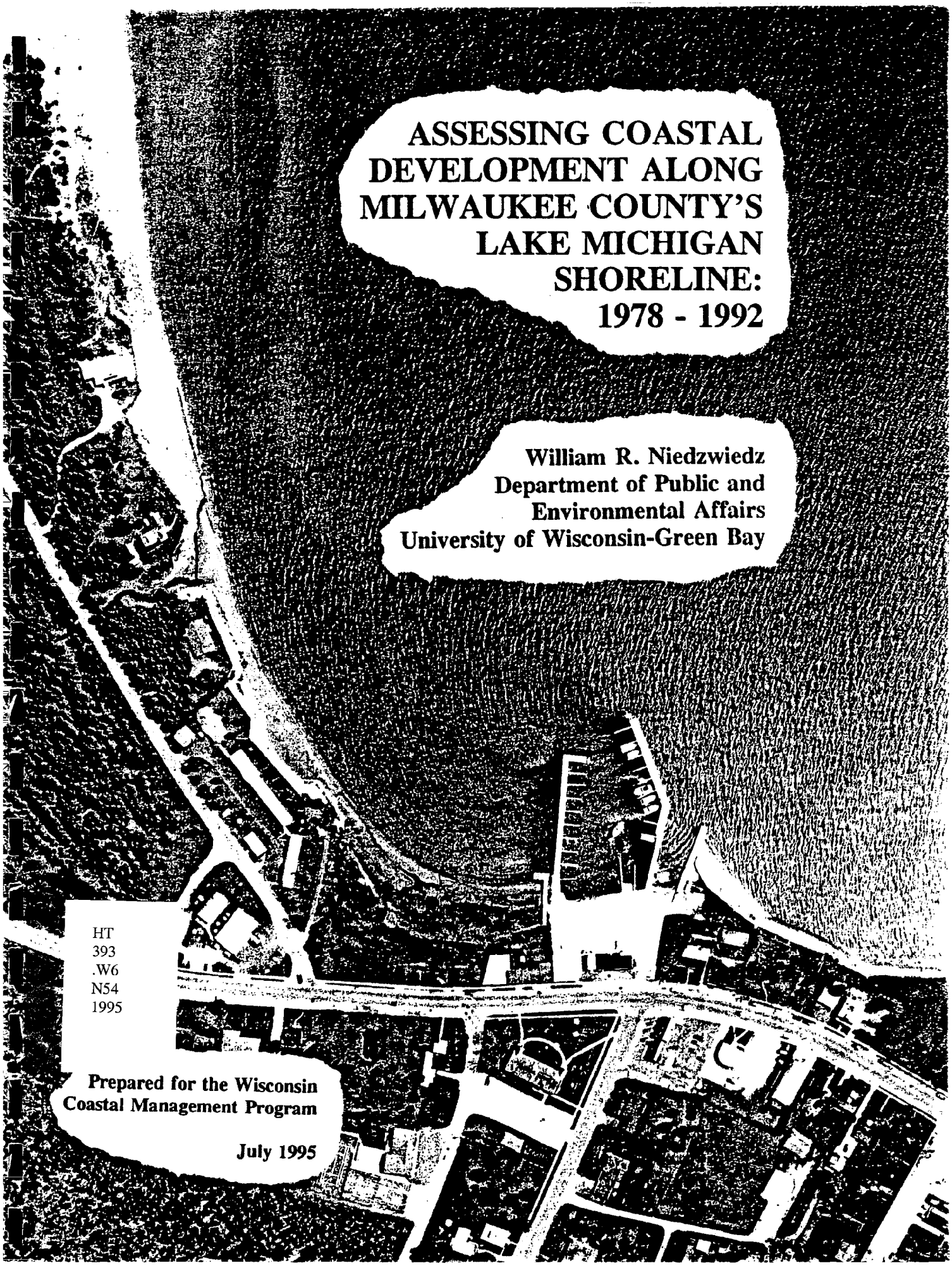

ASSESSING COASTAL DEVELOPMENT ALONG MILWAUKEE COUNTY'S LAKE MICHIGAN SHORELINE: 1978 - 1992

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THE WISCONSIN COASTAL MANAGEMENT PROGRAM, part of Wisconsin Department of Administration, and overseen by the **WISCONSIN COASTAL MANAGEMENT COUNCIL**, was established in 1978 to preserve, protect and manage the resources of the Lake Michigan and Lake Superior coastline for this and future generations.

The Project Team

This project required coordination and completion of several steps including map documentation, photo preparation, photo interpretation, digital area/linear measurement and data sheet preparation. The following students worked as a team to help complete this project.

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Assessing Coastal Development Along Wisconsin's Great Lakes Shoreline: 1978 - 1992

Coastal Management Program Contract No. 840005-501.15

INTRODUCTION

The Wisconsin Coastal Management Program mission includes developing an understanding of change along the state's Great Lakes shoreline. Such change, of course, can be natural or human-based. This study was undertaken to document natural and human-based development within the coastal zone of the state's Lake Michigan and Lake Superior shorelines. The Wisconsin legislature has defined coastal zone as land within 1,000' (304.8 meters) of the shoreline (Ordinary High Water Mark - OHWM).

Future coastal zone planning and risk assessment requirements defined the types of data to be collected. Assessment of risk to structures built in the coastal zone requires a temporal analysis of structural development and shoreline modification(s). Planning of the coastal zone requires, as well, determination of the natural resource base. This study utilized U.S. Army Corps of Engineers historic color aerial photographs taken in 1978 and 1992.

This report documents both the original and amended contract to assess natural and developmental change within the coastal zone of Wisconsin's Great Lakes shorelines. Although the original contracted work was interrupted to include elements of the amended contract, no attempt will be made in this report to keep separate original vs. amended objectives, procedures or results. Goals of the amended contract include and expand those of the original.

PROJECT GOALS

Planning and assessment of hazards within the coastal zone defined the goals of this study. Within the Lake Michigan and Superior coastal zones, project goals included:

- Development of land use databases for 1978 and 1992
- Development of 1978 and 1992 databases of human modification of the shorelines
- Develop a database of built structures for 1992

Additional goals included:

- Assess land use change within the coastal zone from 1978 to 1992
- Assess human modification of the shoreline from 1978 to 1992

STUDY AREA

The project study area comprises the Wisconsin portion of the Lake Michigan and Lake Superior coastal zone (Figure 1). In 1982, the Wisconsin state legislature defined coastal zone as being that land within 1,000 feet (304.8 meters) of lake shoreline. Accordingly, the study area represents a 1,000' wide

Figure 1. Coastal Counties of Lake Michigan and Lake Superior

zone, the landward boundary of which is parallel to the coastline.

PROJECT METHODS

Aerial Photography

Using aerial photos to assess coastal development requires clear statement of goals, appropriate definition of coastal zone, meaningful classification scheme, appropriate historical and current aerial photos, appropriate interpretation procedure and method of documentation, and trained personnel.

Application of aerial photography to assess urban and natural resource features is documented well (Smith, 1968; Avery and Berlin, 1985; Lo and Noble, 1990; Ciciarelli, 1991; Boge et al., 1992; Hinckley and Walker, 1993). Specific applications to urban/human activities cover a wide range including urban nonpoint pollution assessment (Kim and Ventura, 1993), gully erosion analysis (Welch et al., 1985), historical analysis of urban development into coastal wetlands (Niedzwiedz and Batie, 1984), identifying structural additions to urban residential property (Niedzwiedz, 1990), and studying agricultural land use (Marsh et al., 1990).

Aerial photos have been used to map archeological sites, urban features, and to document changes to the landscape (Smith, 1968). MacConnell (1975) reports the use of black and white aerial photography (scale 1:20000) to map 20 years of land use change within the state of Massachusetts, including the coastal zone. As part of a larger Great Lakes study, the International Joint Commission (1993) used 1:24000 scale photos to map land use features along the Berrien County, Michigan segment of the Lake Michigan shoreline. Results of the photo analysis were used to assess residential riparian erosion/recession rates caused by fluctuating water levels.

Wisconsin's coastal zone includes diverse land use, from forests and wetlands, to land devoted to agricultural or urban uses. The uses of aerial photos long have been applied to study such land uses. Befort and Viliman (1985) studied aerial photos to classify forest habitat. McCarthy et al. (1982) evaluated spruce-fir forests to aid management. Wetlands analysis is possible with aerial photos of appropriate format, scale and seasonal timing. Scarpace et al. (1981) used digitized aerial photos to map wetlands, while Ferguson et al. (1993) and Barrett and Niering (1993) have monitored sawgrass habitat and marsh vegetation change using aerial photos.

Extensive use of aerial photography has been directed at coastal resources. Scherz and Van Domelsen (1973) used aerial photos to help assess water quality in Lake Superior near Duluth, Minnesota. Numerous studies have been made with aerial photos to aid management of coastal resources (Benton et al., 1978; Hill et al., 1985; Norton et al., 1985; Welch et al., 1992), to address change in coastal wetlands (Lyon and Greene, 1992), and to

examine urban development into coastal wetlands (Niedzwiedz and Batie, 1984).

Project Aerial Photos

In 1978, the U.S. Army Corps of Engineers (USACE) obtained panchromatic color aerial photos of the Wisconsin portion of the Lake Michigan coastline. In 1992, USACE obtained color aerial photo coverage of the Wisconsin portion of both Lake Superior and Lake Michigan coastlines. Both the 1978 and 1992 photos were flown at a scale of 1:6000 (1" = 500') and enlargements made at 1:2400 (1" = 200'). The 1978 photos were taken April 16th. The 1992 photos were flown May 13th.

Unlike most historical aerial photos covering the same area and flown at the same scale, the USACE photos of 1978 and 1992 were not flown with coincident photo centers or coverage. No individual flight lines were documented for the 1978 photos. Beginning at the Michigan border, the 1978 photos were taken incrementally to the Illinois border. Photos are documented with the photo date and photo number on the northern edge of each photo.

Flight lines were documented for the 1992 photos. Flight line #1 begins just south of the Wisconsin-Illinois border. The northern edge of each 1992 photo displays the photo date, flight line and photo number.

Both the 1978 and 1992 photo contact prints (1:6000) were flown to produce stereo coverage of the coastline. Adjacent photos overlap (endlap) about 60% with each other. The enlarged photos (1:2400) available for this study represent every other photo contact print, therefore, only photographic, not stereo coverage, is provided by the enlarged photos. Approximately 1,800 photos (1:2400) cover Wisconsin's Lake Michigan shoreline, 900 for each flight year. About 1,200 photos covering the shoreline from Marinette to Sheboygan are on file at the Green Bay office of USACE. The Waukesha office of USACE has on file about 600 photos covering the shoreline from Sheboygan to the Illinois border.

Photo Preparation

Photos used in this study are owned by USACE. As a result, all photo documentation and interpretive work was applied to acetate affixed to each photo. Preparing photos for interpretation included the following:

1. Affix label and document photo number/flight line, photo date and Public Land Survey System (PLSS) information.
2. Mark photo fiducials (orange ink). Fiducials allow the registration of acetate overlays to the photos, if required.
3. Mark control points (orange ink). Typically these points are road intersections and,or buildings, stable objects

that could be referenced against controlled maps for future mapping applications.

4. Locate and mark interpretation boundary lines (black ink). These lines are used to denote a common boundary between adjacent photos. Land use interpretive lines end at these boundary lines, which eliminates redundant interpretive work.
5. Locate, mark and label PLSS section lines (red ink).
6. Locate, mark and label civil boundary lines (green ink).
7. Locate and mark 1,000′ coastal zone boundary line (blue ink). A divider was used to scribe a line 1000′ away and parallel to the line defined by land meeting water. In cases where large streams entered Lake Michigan, a straight dashed line was drawn to represent a continuation of the shoreline.
8. Locate and mark top of bluff, and bottom of bluff if slumpage is evident (black ink). In practice, these lines were not drawn until the shoreline portion of the classification scheme was applied to the photos. Refer to the section Photointerpretive Process (page 11) for additional discussion.

Aerial Photo Interpretation (API)

The landscape within the coastal zone can represent a complex mix of natural to urban uses. The land use classification scheme developed for this study addresses the complexity of Wisconsin's coastal zone. The scheme is a modification of the scheme developed by International Joint Commission (1993) and includes the general use categories of residential, commercial, industrial, transportation, extractive, agricultural, natural, open land and other uses. Land uses have been measured by area (acres, hectares). Structures per land use have been located and marked for spatial reference. Structures are tallied by type for 1992.

Modification of the shoreline also has resulted. Sea walls, revetments, groins and permanent docks have been constructed. Sea walls and revetments are linear types. Their interpretation and measurement are presented in feet (meters). Groins and docks were counted.

CLASSIFICATION SCHEME

Residential Land

All residential areas include infrastructure to service the area. Boundary placement is made to separate residential areas by type. No attempt is made to distinguish roads/streets from the residential areas they serve. This convention is true for other classification types as well.

111 Multi-Family: Medium to High Rise. Large residential structure of five (5) or more stories. Access roads, parking areas, open space and recreational facilities associated with the structure(s) would be included in the type.

112 Multi-Family: Low Rise. Large residential structures up to four (4) stories. Access roads, parking areas, open space and recreational facilities associated with the structure(s) would be included in the type.

113 Single Family, Duplex. Structures large and small used for residential use. The type includes lawn, landscaped areas, garage and driveways. Duplex structures are identified by twin driveways or a very wide driveway leading to an architecturally balanced structure.

115 Mobile Home Park. Residential area developed exclusively for mobile units.

Commercial and Industrial Land

Commercial land includes three (3) types: central business district; shopping center/mall; and, neighborhood business district. Each type includes all building structures, access roads/streets, parking facilities and other features commonly associated with each type.

121 Central Business District (CBD). Commercial land predominantly used for distribution or merchandizing of goods and services. Stores, hotels, office buildings, parking facilities and smaller warehouses constitute the components of this type. The CBD spatially is tight, vegetation is rare.

122 Shopping Center/Mall. These commercial areas have developed away from the CBD. The type includes both "strip" type development and malls. Structures can range from large, flat roofed and rectangular (centers) to large, geometrically shaped. Both types include large parking areas adjacent to or completely surrounding the commercial structures.

124 Neighborhood Business District (NBD). This type denotes small commercial areas within, or adjacent to residential areas. The type may be found in established or newer subdivision areas. NBD structures can range from conventional architecture to unusual geometric shapes. Small parking areas are associated with NBD commercial areas.

126 Institutional Land. The type reflects areas devoted to public or quasi-public uses. Examples include schools, churches, hospitals, prisons, etc., and their associated "grounds," green space, landscaping and parking facilities. When located within the CBD, public buildings without "grounds" often cannot be identified on aerial photos and would be classified as commercial (121).

Industrial Land

138 Industrial Park. The type includes both heavy and light industrial use areas.

Heavy industrial land contains facilities for the manufacture, storage and assembly of raw or partially processed products such as machinery, metals, chemicals, petroleum, or electrical power. Such industries often have large smokestacks and large storage areas. Warehouses and transportation facilities for bulk products and an open and interrupted street pattern characterize this type.

Light industrial land contains facilities for the manufacture or assembly of smaller, partially processed products such as electronics, appliances, and other secondary process products. Large smokestacks or raw material storage facilities are never present. Many modern light industries are well landscaped and are indistinguishable from commercial activity on aerial photographs.

Transportation Land

141 Air Transportation. Includes areas with airports and associated facilities, landing strips, hangers, parking areas and adjacent open areas.

142 Rail Transportation. This type includes railyards, terminal freight and storage facilities as well as stations for passengers. The type may include liquid storage facilities such as tank farms.

143 Water Transportation. This designation is applied to several water-based areas, including docks, warehouses and related land-based facilities for water transportation and commercial fishing. The type includes, as well, public marinas and their associated facilities: boat slips, buildings and parking areas.

143.1 Private Marina. Boat mooring areas adjacent to residential land are designated as private marinas. Often such areas include a protected slip(s), dredged waterway and,or a permanent docking structure built into the waterway.

143.2 Public Boat Landing. This type is applied to boat launching areas. Typically, facilities include only a ramp(s) from which boats may be launched and parking areas.

144 Divided Highway. This type includes transportation corridors with median strips between lanes. Typically, such roads are four or more lanes wide. Local streets are not included in this type.

145 Communications. Facilities and structures devoted to communications. These include radio/television towers, lighthouses and their grounds, buildings and parking areas.

146 Utilities. This type includes facilities for the production and distribution of energy. Such areas can include large buildings, towers, roads/parking facilities and, in the case of coal fired plants, large piles of raw coal.

147 Sewage Treatment Plant. Buildings, treatment lagoons, parking areas, access roads and grounds are included in this type.

148 Landfill. Landfill sites used to bury garbage define this type. Landfills cover an extensive area and are dominated by large excavated areas, mounds of exposed soil and access roads.

Extractive Land Use

171 Open Pit. The type represents open pit mining areas for extraction of sand, gravel, stone or rock. The type includes access roads and any structures.

172 Underground Mine. Mining of underground resources via shaft extraction. Surface features captured on aerial photos would be limited to small structures and access roads.

173 Well. Features associated with wells are limited. Identification of wells using only aerial photos is difficult.

179 Other Extractive Uses.

Agricultural and Natural Land

181 Abandoned Field (AF). These are agricultural units reverting to wild land. Woody vegetation and grass are abundant but tree crown cover is less than 30%. If tree crown cover were greater than 30%, the land would be classified as forest.

182 Agriculture Active (AG). Tilled or tillable crop land which is or recently has been intensively farmed. The boundaries on the ground usually are sharply defined and well maintained. The land supporting farm buildings is included as part of this type.

183 Forest (F). Areas of forest, deciduous, coniferous or mixed, having canopy closure of at least 30%. Areas with less than 30% canopy closure are classified as abandoned field.

184 Heath (H). Areas of heath plant community as well as grass, shrubs, and other low vegetation found on poor sandy soils.

185 Open Water (W). Areas of open water found in lakes, rivers and large streams. Water depth is greater than three feet during the growing season. The boundary of coastal water is located by drawing a line at the river mouth to connect the edges of the coastline, or man-made features like roads, railroads or bridges crossing rivers or inlets are used to establish such a line.

186 Rock Ledge (RL). Rock outcrop areas at the coastline or within the coastal zone. Such outcrops are common in Door County.

187 Slump Zone (SL). Land located between upland bluff and beach. Slump zones begin at the bluff line and slope down to the beach.

188 Wetland (WT). This type covers the full spectrum of wetlands. These include seasonally flooded flats, shrub swamps, meadows, bogs, shallow and deep marshes, and forested wetlands. Each is described below.

Seasonally flooded basins or flats occur principally on stream floodplains. The most common plants are grasses and herbaceous species. The soil is waterlogged or covered with water during spring freshets, but well-drained during the growing season.

Shrub swamps often have waterlogged soil during the growing season, as much as six (6) inches of water may be present. Vegetation types include elder, buttonbush, dogwood and willow. Sedges usually are present in tussocks.

Meadows are vegetated with grasses, rushes and sedges. Soils are waterlogged through most of the growing season. Surface water is present only for a short period during the spring.

Bogs are unique wetland types that support a distinctive plant community, including most of the following: heath shrubs, cranberries, pitcher plants and sedges. Scattered black spruce, tamarack and red maple may be present. A mat of sphagnum moss is the most common feature of bogs.

Shallow marsh is wetter than meadow. The soil is completely waterlogged and often covered with up to six inches of water during the growing season. The predominant vegetation is emergent, including such plants as cattails, bulrushes, burreed, pickerelweed and arrowhead with some grasses and sedges present. The type is common to open water bodies.

Deep marsh has water depth ranging from six inches to three feet. Fairly large open water areas are bordered by, or interspersed with, emergent vegetation like that found in shallow marsh. Floating and submergent plants such as water lilies, duckweed, watershield and pondweeds also are present.

Forested Wetlands. This type represents areas of moist to saturated soil covered by forest canopy. The type is difficult to identify without stereo photography and,or with "leaves-on" photography.

Open and Other Land

191 Outdoor-Public Assembly

192 Urban Open Lots. Urban open is undeveloped land lying idle in the midst of urban areas or adjacent to them. This type includes land which has been cleared for urban development of an unknown use..

193 Outdoor Recreation. Outdoor recreation types are either mainly for participation, mainly for spectators, or are environmental in character. Each recreational type includes the recreational complex: access roads, parking facilities, buildings and other related facilities.

194 Cemeteries

Shoreline Modification

Development along the lakeshore often means modification at, or near, the shoreline. Land along the lakeshore is exposed to significant erosional forces. Recession of land mass is common. Agricultural and urban land uses destabilize shoreland, in effect accelerating erosion and land recession. To protect real estate and property, many property owners have constructed walls or revetments along their shoreline. Some owners also have built non-flow-through docks at the shoreline to provide mooring and protection for their boats. Groins, large rock structures perpendicular to the shoreline, have been built along Wisconsin's Lake Michigan shoreline.

195 Sea Walls (V 195 V). These structures are built parallel to the shoreline and typically are well defined, linear

features. Construction materials can include concrete, wood or interlocking sheet steel.

196 Revetments (V 196 V). Large rock or slab structures built parallel to the shoreline. Interpretively, revetments are less well defined, and appear wider than do sea walls.

197 Groins (* [red]). Groins are large rock structures built perpendicular to the shoreline into the water. Except for their distinct orientation and placement, groins appear similar to revetments.

198 Non-Flow-Through Dock (* [blue]). Such docks are permanent structures built into near-shore waters. Typically these docks are straight, their upper surface wide and well defined.

Structures - Industrial, Commercial and Residential

On the 1992 photos, buildings within the coastal zone are classified by type and location. Using a template of rectangles, for each building, a rectangle is selected that best represents the area of the building's "footprint." The selected rectangle then is positioned so that the leading edge of the building (relative to the shoreline) is located. Buildings for 1978 were counted by type. However, due to photo format differences, comparison of 1978 and 1992 structural counts may be inaccurate.

THE PHOTOINTERPRETIVE PROCESS

After photo preparation, each photo was interpreted using the classification scheme defined above. Area (land uses), linear (shoreline modification) and point (urban structures, groins, docks) types are represented in this study. Lines and,or symbols were used to define all types. Area types are represented by perimeter boundary lines and symbols to define and identify the areas. Line types representing modification to natural shoreline were defined using both lines and symbols. All area and line type symbols are recorded in black ink. Point types are defined by symbols and colored ink (see above).

Modifications to the shoreline, such as sea walls or revetments, are delineated by placing (painting) the 'V' symbol at the beginning and end of the modification. The type of modification is represented by placing the appropriate number between the 'V' symbols. For example, 195 positioned between two 'V' symbols means that a sea wall has been built along this section of shoreline. Shoreline classification was conducted before land use so that land use boundary lines placed along the shoreline would not 'hide' shoreline information.

Groins and non-flow-through docks were defined by point symbols (see above). In both cases, the symbol was placed at the point where the structure meets land. As discussed above, for

1992, buildings also were classified using point symbols. The delineation of buildings represents the last API procedure.

MEASUREMENT OF AREA, LINE AND POINT TYPES LOCATED WITHIN THE COASTAL ZONE

Area types (land use polygons) and line types (shoreline modification) measurements were made using the hardware/software facilities of the GIS Lab at the University of Wisconsin-Green Bay. Photo acetate overlays were affixed to large-format digitizers and each land use polygon digitized along the perimeter. Measurements recorded in square inches were converted to acres/hectares. Line measurements (in inches) of shoreline modifications were made using digitizers as well. Linear inch measurements were converted to linear feet/meters for each type of modification.

Point types (groins, structures) simply were tallied by count for each type. The area covered by each acetate was broken into civil jurisdiction and PLSS section designations. Measurements (above) were separated by civil and PLSS designations as well, and documented permanently on each acetate overlay.

TALLY OF DATA

Measurements recorded on each photo acetate were transferred to data sheets. Three (3) levels of data sheets were used: PLSS Section Data; Civil Jurisdiction Summary Data; and County Summary Data (Appendix).

PLSS Section Data Sheet: One (1) PLSS Section Data sheet was used for each section located on a photo/acetate. Generally, 1-2 PLSS sections are located on a photo, however, up to four (4) sections per photo were recorded. Section level data sheets record photo documentation including photo year, photo number, county and community(ies) covered, and complete PLSS section location. Also recorded were number of residential, commercial, industrial and institutional structures (1992), area of land use by type, linear distance of sea walls and revetments, and the number of groins and non-flow-through docks.

Civil Jurisdiction Summary Data Sheet: This tally sheet summarizes the data for all PLSS section sheets found within each township, village or city. The sheet records photo year, county, name of civil jurisdiction, a complete listing of PLSS sections included in the summary, as well as all land use, shoreline and structure count data discussed above.

County Summary Data Sheet: The County Summary sheet summarizes all data for the towns, villages and cities located within the county. Documented information includes photo year, county name, an alphabetical listing of all civil jurisdictions within the county, and a summary of all land use, shoreline and

structure count data reported on Civil Jurisdiction Summary Data sheets.

LIMITATIONS AND SOURCES OF ERROR

The U.S. Army Corps of Engineers contracted for aerial photography of the Wisconsin portion of the Lake Michigan shoreline on April 21, 1978 and May 19, 1992. Both sets of photos are 1:6000 scale and panchromatic color, however, the 1978 photos are "leaves-off" while the 1992 photos are "leaves-on."

Copies of the original stereo photos (1:6000 scale) were not available for this study. Instead, enlargements (1:2400 scale) of the original photos were borrowed from Corps district offices in Green Bay and Waukesha. The enlargements provided photographic coverage only, not stereo coverage. Normally, for a project of this magnitude, photos would have been taken to meet the specific objectives of the study. The enlarged photos used for this project present limitations and introduce error beyond what would be reported with original photos flown specifically for this study. Limitations and errors associated with the photographs used are discussed below. Also presented below is discussion regarding methodological inconsistencies.

The following discussion of Limitations and Sources of Error is presented in an attempt to provide the reader a basic understanding of the issues. Any section of the discussion could apply to any of the results reported below. The Results sections of this report present findings without any comprehensive attempt to explain anomalies within, or between, the photo study years (1978 and 1992).

Photo Scale and Enlargements

All vertical aerial photographs not ratioed (enlarged or reduced to a common average scale) or rectified (common tilt/tip corrected to a horizontal reference plane) inherently are scale inaccurate. The original USACE photos (1978 and 1992) were not ratioed or rectified, therefore, their scale varies relative to topographic changes of the coastal zone, tip/tilt of the camera and changing elevation of the camera (aircraft). Enlargements of the original photos simply accentuate the inaccuracies found on the original photos.

Area and linear measurements taken off of the USACE enlarged photos reflect the inaccuracies inherent in those photos. Simple tests of shoreline distances for numerous PLSS sections within each county were conducted to establish linear accuracies of the photos. USGS topo sheets at 1:24000 scale were used to establish base shoreline distance measurements against which photo (1978 and 1992) shoreline distance measurements could be compared. No systematic errors were detected for the 1978 photos. However, only one (1) of 21 tests of the 1992 photos varied in the positive direction from USGS measurements. The remaining 20 tests varied in the negative direction and ranged from -0.8% to

-13.1%. The range of error, for 1978 was -5.3% to +9.6%, while the range of error for 1992 was -13.1% to +1.9% (see Table 1 page 17). Without a test of error for each photo used, there is no means to judge the direction or the amount of error relative to statistics associated with each photo. However, given the range of error found for the 1978 and 1992 photos, it is possible that 1,000 acres (405 ha) (actual) of coastal zone area could be reported as 1,096 acres (444 ha) in 1978 and 869 acres (352 ha) in 1992, a 227 acre (92 ha) difference.

"Leaves-On" Versus "Leaves-Off" Aerial Photography

There are distinct advantages and disadvantages of both "leaves-on" and "leaves-off" aerial photography. However, given the goals of this project, the 1978 "leaves-off" photography offers important advantages over the 1992 "leaves-on" photography. Vegetation in leaf can hide the details of built structures, including buildings and shoreline modifications. Roads can be hidden under tree crowns, as well as portions of lots landscaped and managed as residential land. Leaved canopies increase the effect of shadows. Shadows mask ground, understory and structural information leading to inaccurate interpretation. Land uses and/or structures hidden under the canopy of vegetation or masked by shadows can be underestimated in area, length or count. Land use types particularly affected (underestimated) are single family residential and wetland.

Stereo Versus Photographic Coverage

Both the 1978 and 1992 photo sets were taken to capture stereo (3-D) coverage of the Lake Michigan coastal area. This means that adjacent photos overlap approximately 60%. Stated another way, 60% of the shoreland area located on one photo also is located on an adjacent photo. The shoreland common to adjacent photos is "seen" from two different perspectives which allows stereo viewing (using a stereoscope).

The enlarged photos borrowed from USACE for this study represent photographic coverage only, or every other photo taken of shoreland. While photo (2-D) coverage at large scales can be used to interpret accurately many land use types (agricultural and most urban land), the lack of stereo viewing makes difficult the identification of wetland types and the exact location of bluff lines. Stereo viewing generally would have increased the interpretive accuracy of most land use, structural and shoreline features.

Incomplete Photo Coverage

For this study, the coastal zone is defined as a 1000′ strip of land adjacent and parallel to the shoreline. Occasionally, photo coverage did not include all shoreland within 1000′ of the water. As a result, total land area is underrepresented, the

exact land use types not covered are not known. In such cases, the area not captured on a particular photo was estimated by reference and comparison to coverage photos of the other flight year.

Missing Photo Coverage

Occasionally, photo coverage was missing from the USACE photo library. In such cases, as described above, coverage area missing was estimated by reference to photos of the other flight year. However, the exact land use types and shoreline features not represented on photos remain unknown.

Location of 1000' Coastal Zone Boundary

On each photo set, 1978 and 1992, a boundary line was drawn representing the 1000' coastal zone parallel to the shoreline. This line was located by scribing a landward line parallel to the line defined by the shoreline (where water meets land). The landward extent of the boundary line is a function of shoreline location, which in turn, is dependent on the water elevation of Lake Michigan. USACE (1978, 1992) reports that in April of 1978 Lake Michigan water elevation was about 578.4 feet (176.3 meters) and about 579.16 feet (176.5 meters) in May, 1992. The nine (9) inch difference in water elevation, while seemingly insignificant, could have shifted substantially landward the shoreline in extremely low slope beach or mud flat areas. The result of such a shift would be inclusion of inland areas NOT included in the 1978 coastal zone.

Lack of Beach Type in Classification Scheme

The width or extent of beach is dependent on slope of an area and water elevation. Since changes in the area of beach likely would reflect more the differences in 1978 and 1992 water levels (9 inches higher in 1992) than actual losses/gains due to erosion or development, no beach type was included in the study.

The lack of a beach type does affect measurement of area within the 1000' coastal zone. The landward extent of the coastal zone is 1000' from the shoreline. Any beach area lies between the shoreline and the base of the bluff, however area measurements of land use types were made only for those types lying between the base of the bluff and the interior boundary of the coastal zone. In most cases, beach strips represent only about five (5) acres per photo.

Positional Changes to the Shoreline: Natural vs. Urban Development

As discussed above, the landward extent of the 1000' coastal boundary is dependent on the location of the shoreline. Natural changes to shoreline position include both water elevation and

erosion/deposition of soil. Filling of coastal waters to accommodate urban development artificially changes shoreline location. In such cases, not only does the shoreline move "offshore," the interior coastal zone boundary line shifts toward the water. This "shift" in coastal boundaries skews area measurement. For example, in 1978 assume the coastal zone in an area to be all residential and that by 1992 100 acres of lake water is filled to develop commercial land. A "lakeward" shift in the location of the shoreline will occur due to the land filled for commercial use. However, this "shift" in the shoreline created by the filled commercial site also will result in a shift toward the water of the interior coastal zone boundary. The effect of the latter shift will be that 100 acres of residential land will not be included as part of the 1992 coastal zone. In such a case, the "raw' statistics misleadingly suggest that 100 acres of residential land use were eliminated to make room for 100 acres of commercial use.

RESULTS

Milwaukee County Statistics

Milwaukee County communities lying within the Lake Michigan coastal zone include the villages of Bayside, Fox Point, Shorewood and Whitefish Bay, and the cities of Cudahy, Milwaukee, Oak Creek, St. Francis and South Milwaukee. The area measured within the coastal zone of Milwaukee County was 3,272 acres (1,325 ha) in 1978 and 3,291 acres (1,332 ha) in 1992. This represents a difference of 19 acres (7.7 ha) or about 0.5%. The discrepancy likely is the result of errors inherent in the enlarged aerial photos, as discussed on pages 12 through 15.

Using USGS maps as control, tests were conducted on the linear accuracy of the Milwaukee County photos. Results of tests applied to the 1978 photos indicate some departure (-4.9% and -5.3%) from USGS measurements. Results of tests applied to the 1992 photos indicate errors of +1.9% to -6.9%. The range of error could yield a 235 acre (95 ha) difference between the 1978 and 1992 totals (Table 1).

Statistical summaries for Milwaukee County and all communities included in this study are located in the Appendix.[1] Summary data sheets present land use types by area, structural counts by type (1992), shoreline modification types by length, and a count of shoreline structures by type. Data were collected at the PLSS section level. While the section level data sheets are not included in this report, copies are available upon written request.

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[1]Area figures used in the Results discussion reflect totals (not rounded) reported on the original tally sheets. Figures presented on the tally sheets found in the Appendix of this report have been rounded to the nearest whole number.

Table 1. County Results of Linear Accuracy Tests

Percent Deviation From USGS Base Map Measurements

County	1978 Enlarged Photos (1:2400)	1992 Enlarged Photos (1:2400)
Brown	-0.4%	-8.5%
	0.03%	-5.5%
Door	1.3%	-1.1%
	3.9%	-3.6%
Kenosha	-2.5%	-9.0%
	3.1%	-1.6%
Kewaunee	-1.5%	-5.4%
	2.1%	-9.6%
Manitowoc	-1.7%	-6.4%
	2.0%	-7.4%
Marinette (one test)	9.6%	-1.7%
Milwaukee	**-4.9%**	**-6.9%**
	-5.3%	**1.9%**
Oconto	2.9%	-10.8%
	8.5%	-13.1%
Ozaukee	0.2%	-5.7%
	1.3%	-4.4%
Racine	-3.0%	-5.0%
	2.2%	-0.8%
Sheboygan	-2.5%	-1.2%
	4.6%	-3.0%
Mean	0.95%	-5.18%
Range	-5.3% to 9.6%	-13.1% to 1.9%

Residential Land

Within the 1992 coastal zone of Milwaukee County, 3,581 residential structures were identified on 808 acres (327 ha) of land. Of the total were 2,301 residential units (single family or duplexes), 1,131 detached garages and 145 sheds. In 1978, 847 acres (343 ha) of land were developed for single family/duplex units compared to 800 acres (324 ha) in 1992. The lost area (47 acres, 19 ha) represents 5.5%. In 1978, over 16 acres (6.5 ha) of land was used for high-rise multi-family units. By 1992, total area used for this type dropped to 5.7 acres (2.3 ha). One (1) structure was observed. Also in 1992, (3) low-rise multi-family units were recorded on 2.9 acres (1.2 ha) of land. Since the 1992 photos are "leaves-on," these numbers likely underestimate the actual number of structures and area devoted to residential uses. In 1978, 866 acres (351 ha) of residential land was measured.

Commercial and Industrial Land

Commercial land represented 134 acres (54 ha) in 1992 and 104 acres (42 ha) in 1978. Sixty-four (64) commercial structures were noted within the coastal zone. Over the 14 year period central business district decreased by 24.6 acres (10 ha) while neighborhood business district increased by 5.8 acres (2.3 ha). Institutional land increased dramatically from 59 acres (24 ha) to 108 acres (44 ha) for the same period. The increase represents 49 acres (20 ha) or 83%.

Industrial land within the coastal zone decreased from 238 acres (96 ha) to 155 acres (63 ha), a loss of 83 acres (34 ha) or 35%.

Transportation Land

One hundred twenty-two (122) structures were located on 422 acres (171 ha) of transportation land in 1992. In 1978, 489 acres (198 ha) of transportation land were reported. The category types rail transportation, public boat landing and communications remained stable at about 30 acres (12.1 ha), 41 acres (16.6 ha) and less than (1) acre, respectively. Two types experienced increases from 1978 to 1992. Private marina increased from 1.9 acres (0.8 ha) in 1972 to 19 acres (7.7 ha) in 1992 while land devoted to sewage treatment facilities increased from 121 acres (49 ha) to 187 acres (76 ha). Of the transportation types observed, three (3) lost area. Land developed for highway decreased by nearly 35 acres (14 ha) or 30% from 114 acres (46 ha) in 1978 to 80 acres (32 ha) in 1992. Utilities decreased from 129 acres (52 ha) to 25 acres (10.1 ha), a loss of 104 acres (42 ha) or nearly 81%. Lastly, area of landfill lost 9.4 acres (3.8 ha), declining from 49 acres (20 ha) to 40 acres (16 ha).

Extractive

Extractive area was not observed in 1978. However, 29 acres (11.7 ha) of open pit extractive area were recorded in 1992.

Agricultural and Natural Land

In 1978, land uses within the category Agricultural and Natural represented nearly 21% of all land within the coastal zone of Milwaukee County. In 1992, this category increased to 23%.

Overall, 94 acres (38 ha) of agricultural and natural lands were gained from 1978 to 1992. Abandoned field area increased by 30 acres (12 ha) from 1978 to 1992, or by 19.1%, however, the important type active agriculture declined by nearly 41 acres (16.4 ha) or by 52% over the same period. All other types observed within this category either remained stable or increased in area. Forest area increased from 292 acres (118 ha) in 1978 to 351 acres (142 ha) in 1992. Open water gained 35 acres over the same period, from 8.2 acres (3.3 ha) to 43 acres (17 ha) while wetland increased from 7.4 acres (2.9 ha) to 13.1 acres (5.2 ha), a gain of 5.7 acres (2.3 ha). Area of slump zone increased by 1.8% or 2.5 acres (1.0 ha) over the 14 year period.

Open and Other Land

The total area of open/other land use types increased by 73 acres (30 ha) or 8.1%, from 899 acres (364 ha) in 1978 to 972 acres (394 ha) in 1992. In 1992, 117 structures were observed including 57 public assembly and 56 outdoor recreational. Most of the total area increase within this category was observed within the outdoor-public assembly type which increased 60 acres (24 ha) from no area in 1978 to 60 acres in 1992.

Shoreline Modifications

Sea walls and revetments are used to protect shorelines from erosion. Significant increases of both types of structures were reported. In 1978, 37,264 feet (11,361 m) of sea wall were reported compared to 42,265 feet (12,886 m) in 1992, representing an increase of 5,001 feet (1,525 m) or 13.4%. However, just as significant is the 8,438 foot (2,573 m), 21% increase in revetment development since 1978. Shoreline revetment was measured at 40,079 feet (12,219 m) in 1978 and 48,517 feet (14,792 m) in 1992. The number of groins developed along Milwaukee County's shoreline increased from 19 to 28 over the 14 year period. Nine (9) non-flow-through docks were recorded in 1992 compared to 10 in 1978.

Results by Community

Village of Bayside

Land within Bayside's coastal zone was measured at 189 acres (76 ha) in 1978 and 187 acres (76 ha) in 1992. The discrepancy represents less than (1) percent. The source of the difference could be photo scale anomalies as discussed above.

In 1992, 68 residential structures were located on 54 acres (22 ha) of land. Most of these structures (62) were single family or duplex. Other structures associated with residential areas included (4) detached garages and (2) sheds. In 1978, 63 acres (26 ha) of residential are reported.

No commercial, industrial, transportation or extractive types were located in 1978 or 1992.

Agricultural and natural areas increased from 67 acres (27 ha) in 1978 to 78 acres (32 ha) in 1992 or by about 10 acres (4.1 ha). The type abandoned field lost 6.9 acres (2.8 ha) during the period while forest land increased by 20 acres (8.1 ha) or 37%. Area of slump zone decreased by 1.6 acres (0.6 ha) to a 1992 total of 0.4 acres (0.2 ha). About 1.5 acres (0.6 ha) of wetland observed in 1978 were lost by 1992.

From 1978 to 1992, shoreline modifications had increased within the village. By 1992, construction led to 325 feet (99 m) of new sea wall on Bayside's shoreline. No sea wall was observed 1978. Revetment increased significantly from 417 feet (127 m) in 1978 to 1,236 feet (377 m) in 1992, an increase of 196%. While no groins were recorded for either study year, (2) non-flow-through docks were recorded in 1992.

City of Cudahy

Coastal zone area within the city of Cudahy was measured at 305 acres (124 ha) in 1978 and 318 acres (129 ha) in 1992. The difference of 15 acres (6 ha) represents 4.9% of the 1978 total area.

In 1992, a total of 142 residential structures were identified on 28 acres (11 ha) (29 acres [12 ha] in 1978) of residential land. Of these, 96 were single family/duplex, 36 were detached garages and (9) were sheds.

For both 1978 and 1992, about 13 acres (5.3 ha) of coastal zone area were devoted to commercial/institutional uses, the greatest portion of which fell into the institutional type. No industrial land was observed within the coastal zone for either study year.

Less than one acre (0.7 acre [.3 ha]) of transportation land was observed in both 1978 and 1992. No extractive uses were observed for 1978 and less than one acre was observed for 1992. The agricultural and natural category decreased from 41 acres (17 ha) to 32 acres (13 ha) for the period studied. Category changes include a 4.4 acre (1.8 ha) decrease in abandoned field and a 6.6 acre (2.7 ha) decrease in forest land. About 31 acres (12.5 ha)

of slump zone area were recorded for each year. Area of the open/other land use category increased by 25 acres (10 ha) from 220 acres (89 ha) in 1978 to 245 acres (99 ha) in 1992. All acreage within this category was devoted to outdoor recreation.

The remaining notable change to be reported includes shoreline modifications. Results indicate a gain of 146 feet (44.5 m) of revetment. Thirteen groins were observed in 1992 compared to 11 in 1978.

Village of Fox Point

In 1992, the coastal zone of the village of Fox Point consisted of 311 acres (126 ha) compared to 329 acres (133 ha) reported in 1978. The difference of 18 acres (7.3 ha) represents 5.5% of the 1978 total coastal zone area.

Residential land encompassed 193 acres (78 ha) in 1992. Observed residential structures totaled 369, of which 299 were single family/duplex. Other structures associated with residential use included 49 detached garages and 21 sheds. In 1978, 195 acres (79 ha) of residential land were recorded.

In 1992, no commercial, industrial, transportation or extractive uses were observed within Fox Point's coastal zone. While no commercial, industrial or extractive areas were observed in 1978, 4.6 acres (1.9 ha) of highway right-of-way were recorded.

In 1992, 95 acres (38 ha) of area were identified within the agricultural and natural use category, down from 103 acres (42 ha) in 1978. Of these were 3.0 acres (1.2 ha) of abandoned field, 87 acres (35 ha) of active agriculture and 4.6 acres (1.9 ha) of slump zone. Open water was observed at 0.1 acres (0.04 ha). The major changes within the category involved the types abandoned field, up by 2.7 acres (1.1 ha) from 0.3 acres (0.1 ha) in 1978; forest, down by (8) acres (3.2 ha) from 95 acres (39 ha); and area of slump zone, down by 3.4 acres (1.4 ha) from (8) acres (3.2 ha).

In the open/other land use category, 22 acres (9 ha) were identified as outdoor recreation in 1992, down from 25 acres (10.3 ha) in 1978. Other uses made up less than one acre in 1992.

Considerable shoreline modification has occurred since 1978. In 1978, 3,612 feet (1,101 m) of sea wall were recorded compared to 3,304 feet (1,007 m) in 1992, a loss of 308 feet (94 ha). Revetments, however, increased substantially from 2,948 feet (899 m) in 1978 to 7,502 feet (2,287 m) in 1992. The increase in revetment represents 4,554 feet (1,388 m) or 154%. No groins were observed in 1978, by 1992, (5) groins had been constructed. Non-flow-through docks declined from (3) in 1978 to (1) in 1992.

City of Milwaukee

In 1992, a total of 1,030 acres (417 ha) of coastal zone fell within the city of Milwaukee compared to 1,019 acres (413

ha) in 1978. The 11 acre (4.5 ha) difference represents 1% of the 1978 total.

In 1992, 1,270 residential structures were observed on 161 acres (65 ha) of land. Total residential structures included (2) low-rise multi-family units, 742 single family/duplex units, 482 detached garages and 44 sheds.

Commercial land increased by 18.2 acres (7.4 ha) from 55 acres (22 ha) in 1978 to 74 acres (30 ha) in 1992. The increase represents nearly 33%. Over the 14 year study period, considerable change occurred within commercial types. CBD area lost 24.6 acres (10 ha), from 40.5 acres (16.4 ha) in 1978 to 15.9 acres (6.4 ha) in 1992. The type neighborhood business district increased by 6 acres (2.4 ha) over the same period. However, the main benefactor of growth was land devoted to institutional uses, which increased by nearly 37 acres (15 ha) from 13 acres (5.2 ha) in 1978 to 50 acres (20 ha) in 1992. A total of 38 commercial category structures were observed in 1992, including 23 institutional and 11 neighborhood business district.

Land classified as industrial fell from 142 acres (57 ha) in 1978 to 104 acres (42 ha) in 1992, a loss of 38 acres (15 ha) or 27%. A total of 112 industrial structures were observed within the coastal zone.

Coastal zone land devoted to transportation category uses covered 235 acres (95 ha) in 1992 compared to 255 acres (104 ha) in 1978. In 1992, observed structures of this category totaled 39. Eight separate types were observed for both study years. Of these, three remained stable including rail transportation (about 30 acres [12 ha]), communications (less than [1] acre) and utilities (about 23 acres [9.5 ha]). Two types lost area between 1978 and 1992. These include highway area which lost about 20 acres (8.1 ha), declining from 91 acres (37 ha) in 1978 to 72 acres (29 ha) in 1992 and landfill, which lost 24 acres (9.8 ha), from 49 acres (20 ha) to 25 acres (10 ha). During the period three land use types within the category increased in area: private marina increased by 10.5 acres (4.2 ha), from 1.5 acres (0.6 ha) to 12 acres (4.9 ha); public boat landing gained nearly (6) acres (2.4 ha), from 34 acres (14 ha) to 40 acres (16 ha); and sewage treatment facilities increased by 10 acres (4.1 ha), from 23 acres (9.2 ha) to 33 acres (13.2 ha).

No extractive uses were observed for either study year.

The category of agricultural and natural land uses increased in total area from 33 acres (13.2 ha) in 1978 to 63 acres (25.5 ha) in 1992, a finding which runs counter to results observed elsewhere within the state. In 1978, only two (2) land use types were observed within this category, together totally 33 acres (13.2 ha). In 1978, abandoned field covered 4.1 acres (1.7 ha) while forested areas covered 28.5 acres (11.5 ha). In 1992, abandoned field covered 5.9 acres (2.4 ha), a gain of 1.8 acres (0.7 ha) while forest areas covered 22.8 acres (9.2 ha), a loss of 5.7 acres (2.3 ha). The type open water increased dramatically from 1978 to 1992. While no open water area was observed in 1978, 34 acres (13.8 ha) were recorded in 1992.

In 1978, 354 acres (143 ha) of open/other land were observed, by 1992, the total had increased by 40 acres (16.2 ha) to 394 acres (160 ha). In 1992, observed structures totaled 79. No outdoor-public assembly area was observed in 1978, however, 60 acres (24 ha) were recorded in 1992. Results indicate that the area of urban open lot declined by 18.5 acres (7.5 ha), from 43 acres (17.5 ha) in 1978 to 25 acres (10 ha) in 1992. Lastly, the type outdoor recreation remained stable at about 310 acres (125 ha) for both study years.

In 1978, 24,559 feet (7,487 m) of sea wall were recorded within the city of Milwaukee. By 1992, 5,384 feet (1,641 m) of sea wall had been added for a total of 29,943 feet (9,129 m). Revetments, on the other hand, declined by 6,619 feet (2,018 m), from 24,460 feet (7,457 m) in 1978 to 17,841 feet (5,439 m) in 1992. The structures groins and non-flow-through docks declined as well, groins from (5) to (2) and docks from (3) to (2) over the 14 year study period.

City of Oak Creek

The coastal zone for the city of Oak Creek was determined to be 456 acres (185 ha) in 1978 and 461 acres (187 ha) in 1992. The difference of (5) acres (2.0 ha) represents 1.1% of the 1978 total coastal zone area.

The amount of residential land located within the coastal zone was less than (1) acre in 1978. No residential area was observed in 1992.

No commercial land uses were identified in 1978 or 1992. In 1978, land devoted to industrial use covered 77 acres (31 ha), however, this total dropped to 29 acres (12 ha) by 1992, a loss of 48 acres (19.5 ha) or 62%.

Total transportation land remained fairly stable, 152 acres (62 ha) were recorded in 1978 compared to 162 acres (66 ha) in 1992. However, considerable change occurred within the types of this category. For example, in 1978, 60 acres (24 ha) of utilities were observed compared to no acreage in 1992 while sewage treatment plant increased from 92 acres (37 ha) to 147 acres (60 ha). Landfill area, not observed in 1978, gained nearly 15 acres (6 ha) by 1992.

No extractive uses were observed in 1978, however, 2.2 acres (0.9 ha) of open pit mine were recorded in 1992.

Agricultural and natural lands made up 49% and 57% of the city's coastal zone area for 1978 and 1992, respectively. Total agricultural and natural lands covered 225 acres (91 ha) of the coastal zone in 1978 compared to 264 acres (107 ha) in 1992. Abandoned field increased in area from 92 acres (37 ha) to 102 acres (41 ha) while active agricultural area declined from 49 acres (20 ha) to 38 acres (15.5 ha). The types forest, slump zone and wetland all increased in area during the 14 year period: forest from 45.5 acres (18.4 ha) to 69 acres (28 ha), slump zone from 33 acres (13.4 ha) to 49 acres (20 ha), and wetland from 4.8 acres (1.9 ha) to 5.7 acres (2.3 ha).

Open/other land areas represented 3.2 acres (1.3 ha) in 1992, all area observed within the type as urban open lot. In 1978, 1.9 acres (0.8 ha) of urban open lot were observed.

Since 1978, sea wall development increased from 3,858 feet (1,176 m) to 5,419 feet (1,652 m), an increase of 1,561 feet (476 m) or 40%. Likewise, revetment experienced an increase, from 2,994 feet (913 m) in 1978 to 3,613 feet (1,102 m) in 1992. The increase in revetment represents 619 feet (189 m) or 20.6%. The number of groins dropped from (2) to (1) during the 14 year period.

City of St. Francis

The coastal zone of the city of St. Francis was determined to be 208 acres (84 ha) in 1978 and 216 acres (88 ha) in 1992. The (8) acre (3.2 ha) difference is 3.8% of the 1978 total.

Total residential land located within the 1978 coastal zone was 16.5 acres (6.7 ha) compared to 11.9 acres (4.8 ha) in 1992. In 1992, 90 structures were located within the residential area, of which were 39 single family/duplex, 45 detached garages and 5 sheds. One low-rise multi-family unit was observed on 1.2 acres (0.5 ha) of land.

In 1992, 12 commercial category structures were observed on 45 acres (18.3 ha) of land. Total commercial area in 1978 was 33.5 acres (13.6 ha). Two types within this category were observed. Neighborhood business district remained stable at about 0.7 acres (0.3 ha) for each year. The type institutional increased from 33 acres (13 ha) in 1978 to 44.5 acres (18 ha) in 1992.

Industrial land remained unchanged at 1.0 acres (0.4 ha) over the period.

In 1978, 41 acres (16.5 ha) of transportation area were identified. In 1992, only 1.2 acres (0.5 ha) of transportation land were observed within the coastal zone. For both years, all transportation area was identified as utility.

No extractive uses were observed for 1978, however, over 26 acres (10.6 ha) of open pit mine were recorded in 1992.

Agricultural and natural lands made up 37% of the town's coastal zone in 1978 and 35.6% in 1992. For both 1978 and 1992, 77 acres (31 ha) of coastal zone area were classified within the agricultural and natural lands category. However, considerable internal change occurred over the 14 year period of study. The type abandoned field increased in area from 29 acres (11.6 ha) to 56 acres (23 ha). Active agricultural land decreased from 30 acres (12.1 ha) in 1978 to no area in 1992. Other changes observed were modest. Forest area, for example, increased from 4.5 acres (1.8 ha) in 1978 to 6.8 acres (2.8 ha) in 1992 while open water decreased from 5.9 acres (2.4 ha) to 4.8 acres (1.9 ha). Similarly, a decrease in area was observed within the type slump zone, from 6.7 acres (2.7 ha) in 1978 to 2.4 acres (1.0 ha) in 1992. During the period studied, wetlands increased from 1.1 acres (0.4 ha) to 7.0 acres (2.8 ha).

Open/other land uses increased from 40 acres (16.1 ha) in 1978 to 54 acres (22 ha) in 1992. Urban open lots appear to have increased dramatically from only 1.1 acres (0.4 ha) to nearly 27 acres (10.8 ha) by 1992. The type outdoor recreation declined from nearly 39 acres (16 ha) in 1978 to 27 acres (11 ha) in 1992.

In 1978, 61 feet (19 m) of sea wall were observed compared to 48 feet (14.6 m) in 1992. In 1978, 3,234 feet (986 m) of revetment were documented, this total rose to 7,052 feet (2,150 m) by 1992, an increase of 3,818 feet (1,164 m) or 118%. No groins or non-flow-through docks were observed for either study year.

Village of Shorewood

Land within the coastal zone of the village of Shorewood was measured at 138 acres (56 ha) in 1978 and 151 acres (61 ha) in 1992. The source of the difference (13 acres, 5.3 ha) could be photo scale anomalies as discussed above. The village of Shorewood was one of the sites tested to determine linear accuracy of the enlarged photos. The 1978 photos of Shorewood were determined to deviate -5.3% from USGS 1:24000 maps. The 1992 photos deviated by +1.9% from the USGS basis.

In 1992, 426 residential structures were located on 102 acres (41 ha) of land. Most of these structures (276) were single family or duplex. Other structures associated with residential land include 137 detached garages and 10 sheds. In 1978, 99 acres (40 ha) of residential land were reported.

Results indicate that no commercial or industrial park land was observed for either study year.

Land area devoted to transportation types remained unchanged at 7.0 acres (2.8 ha) for both 1978 and 1992. All such area observed for both years fell into the highway type.

No extractive uses were observed in either year of study.

Agricultural and natural areas increased from 27 acres (10.8 ha) in 1978 to 38 acres (15.4 ha) in 1992. Only three types within this category were observed, abandoned field, forest and slump zone. Abandoned field decreased from 1.1 acres (0.4 ha) in 1978 to no area observed in 1992. However, both forest land and slump zone increased, from 25 acres (10 ha) to 35 acres (14.3 ha) and from 1.0 acre (0.4 ha) to 2.6 acres (1.1 ha), respectively.

Open/other land remained stable during the period studied. Outdoor recreation, the only type observed, increased from 4.7 acres (1.9 ha) in 1978 to 5.0 acres (2.0 ha) in 1992.

From 1978-1992, results suggest total shoreline modifications of sea wall and revetment remained stable. However, considerable change between these types was observed. Sea wall construction decreased from 1,883 feet (574 m) to 761 feet (232 m) while revetment increased from 402 feet (123 m) to 1,502 feet (458 m).

No groins, but (4) non-flow-through docks were recorded for each study year.

City of South Milwaukee

The coastal zone area within the city of South Milwaukee was measured at 315 acres (128 ha) in 1978 and 304 acres (123 ha) in 1992. The 11 acre (4.5 ha) difference is 3.5% of the 1978 area.

In 1992, a total of 259 residential structures were identified on 46 acres (18.5 ha) of residential land. Of these, 144 were of the single family/duplex type, while 76 and 30 were detached garages and sheds, respectively. In 1992, (9) low-rise multi-family units were observed on 6.7 acres (2.7 ha) of land.

In 1992, no commercial land was located in the city's coastal zone. Industrial land covered 21 acres (8.6 ha) in 1992, on which (8) structures were observed. This area represents a gain of 4.2 acres (1.7 ha) over the 17 acres (6.9 ha) observed in 1978.

Although total land devoted to the transportation category remained stable from 1978 (16.5 acres, 6.7 ha) to 1992 (15.9 acres, 6.4 ha), considerable changes within the category were recorded. For example, private marina increased from 0.4 acres (0.2 ha) to 7.0 acres (2.8 ha) while public boat landing areas decreased from 6.2 acres (2.5 ha) to 1.2 acres (0.5 ha). Land devoted to utilities also decreased, from 3.2 acres (1.3 ha) in 1978 to no area observed in 1992. Sewage treatment facilities increased modestly from 6.7 acres (2.7 ha) to 7.7 acres (3.1 ha). In 1992, 13 structures were observed within this category.

No extractive types were noted for either study year.

Agricultural and natural lands covered about 48 acres (19 ha) in both 1978 and 1992. Five (5) land use types within the category were observed and all remained relatively stable over the 14 year study period. In 1978, 18 acres (16.3 ha) of abandoned field were observed compared to 16.3 acres (6.6 ha) in 1992. Forest area increased from 11 acres (4.5 ha) to 12.9 acres (5.2 ha) while open water increased from 0.8 acres (0.3 ha) to 1.9 acres (0.8 ha) over the 14 year period. Two additional types experienced increases in area. Area of slump zone increased from 17.2 acres (7.0 ha) in 1978 to 18.5 acres (7.5 ha) in 1992 while wetland increased from no area to less than (1) acre.

Total Open and Other Lands decreased from 184 acres (74 ha) in 1978 to 171 acres (69 ha) in 1992. In 1978, only 1.9 acres (0.8 ha) of urban open lot were recorded, by 1992 no such areas were observed. A total of 16 structures were noted on 171 acres (69 ha) of outdoor recreation land in 1992. In 1978, 182 acres (74 ha) of outdoor recreation land were recorded.

Shoreline modifications decreased significantly during the 14 year period studied. Sea walls declined by 1,170 feet (357 m), from 1,563 feet (477 m) in 1978 to 393 feet (120 m) in 1992. During the same period, revetments declined by 1,522 feet (464 m), from 2,107 feet (642 m) to 585 feet (178 m). Three (3) groins were observed in 1992, compared to (1) recorded in 1978.

Village of Whitefish Bay

In 1978, land within the village's coastal zone was estimated to be 314 acres (127 ha). The 1992 coastal zone area was estimated to be 321 acres (130 ha). The seven (7) acre (2.8 ha) difference represents 2.2% of the 1978 base.

Residential land covered 233 acres (94 ha) in 1978. In 1992, total residential land covered 223 acres (90 ha). In 1992, a total of 969 structures were documented. Of these, there were 643 single family/duplex units, 302 detached garages and 24 sheds.

Commercial land covered only 2.5 acres (1.0 ha) in 1992, a 1.1 acre (0.4 ha) increase over 1978. No industrial land was observed in 1992 and only 0.6 acres (0.2 ha) was observed in 1978. A total of 11.6 acres (4.7 ha) of transportation land were recorded in 1978, by 1992, the total had dropped to 0.8 acres (0.3 ha). In both years, all transportation land recorded was of the highway type.

No extractive land was observed in either year of study.

Results indicate that agricultural and natural lands increased in area from 1978 to 1992, a trend not common. In 1992, this category had 74 acres (30 ha). Of these, there were 3.4 acres (1.4 ha) of abandoned field, 43 acres (17.5 ha) of forest and 28 acres (11 ha) of slump zone. In 1978, investigators observed no abandoned field, 21 acres (8.6 ha) of forest and 36 acres (14.4 ha) of slump zone. In effect, forest land doubled in area while slump zone area declined by 22.5%.

Twenty-one (21) acres (8.6 ha) of open/other land were observed in 1992 compared to a 1978 total of 10.8 acres (4.4 ha). All such areas were of the outdoor recreation type. Outdoor recreation increased by 11.9 acres (4.8 ha) or 128% since 1978. Urban open lots, 1.5 acres (0.6 ha) in 1978, were eliminated by 1992.

Considerable modifications to the village's shoreline occurred during the study period. In 1992, 2,071 feet (632 m) of sea wall were recorded compared to 1,729 feet (527 m) in 1978. The additional 342 feet (104 m) represents an increase of 19.8%. Revetments increased by 5,523 feet (1,684 m) or 176% during the same period, from 3,141 feet (958 m) to 8,664 feet (2,641 m). While no groins or non-flow-through docks were observed in 1978, by 1992, four (4) groins had been constructed.

REFERENCES

Avery, T.E. and G.L. Berlin, 1985. Interpretation of Aerial Photographs. 4th ed., Brugess Publishing Co., Minneapolis. 554 pp.

Barrett, N.E. and W.A. Niering, 1993. Tidal marsh restoration: trends in vegetation change using a geographic information system. Society for Ecological Restoration. 1(1):18-28.

Befort, W. and J.J. Viliman, 1985. Aerial identification of forest habitats. *Proceedings of the ACSM-ASPRS Annual Convention*, Washington, D.C., Vol. 2, pp. 679-688.

Benton, A.R., Jr., W.W. Snell and C. Clark, 1978. Seasonal aerial photographic mapping of Galveston Island. Coastal Mapping Papers Reprint from Coastal Zone '78, Amer. Soc. Civil Eng., pp. 1205-1222.

Boge, W.E., A.C. Crone and R.J. Ondrejka, 1992. Primary data acquisition - state of the art review. *Photogrammetric Engineering and Remote Sensing*, 58(8):1077-10.

Carlson, H., L.M. Andrews and C.W. Threinen, 1977. *Surface Water Resources of Oconto County*. Wisconsin Department of Natural Resources, Madison, Wisconsin.

Ciciarelli, J.A., 1991. Practical Guide to Aerial Photography. Van Nostrand Reinhold, New York, 261 pp.

Dresen, M. and M.E. Vollbrecht, 1986. Wisconsin's shoreland zoning program: design and direction. *The Michigan Riparian*.

Eastman-Kodak, 1974. *Photography from Light Planes and Helicopters*. Pub. No. M-5, Rochester, N.Y., 25 p.

Evans, B.M. and L. Mata, 1984. Acquisition of 35mm oblique photographs for stereoscopic analysis and measurement. *Photogrammetric Engineering & Remote Sensing*, 50(11):1581-1590.

Ferguson, R.L., L.L. Wood and D.B. Graham, 1993. Monitoring spacial change in seagrass habitat with aerial photography. *Photogrammetric Engineering and Remote Sensing*, 59(6):1033-1038.

Fleming, J. and R.G. Dixon, 1981. *Basic Guide to Small-Format Hand-Held Oblique Aerial Photography*. Canadian Centre for Remote Sensing, Ottawa, Ontario, 81 p.

Hagen, G.F. and J.L. Smith, 1986. Predicting tree groundline diameter from crown measurements made on 35mm aerial photography. *Photogrammetric Engineering & Remote Sensing*, 52(5):687-690.

Heer, R.C. and J.L. Smith, 1986. Estimation of density in young pine plantations using 35mm aerial photography. *Proceedings of the ACSM-ASPRS Annual Convention*, Washington, D.C., Vol. 5, pp. 80-84.

Hill, J.M., D.L. Evans and J. Blackman, 1985. Development of a permit geographic information system for coastal zone management. *Proceedings of the ACSM-ASPRS Annual Convention*, Washington, D.C., Vol. 1, pp. 284-293.

Hinckley, T.K. and J.W. Walker, 1993. Obtaining and using low-altitude/large-scale imagery. *Photogrammetric Engineering and Remote Sensing*, 59(3):310-318.

International Joint Commission, Committee 2, 1993. Detailed Site Study - Berrien County, Michigan: Final Report, 75 pp.

International Joint Commission, 1993. Great Lakes Water Level Reference Study. Working Committee 2. Land Use and Shoreline Management Task Group Report, 99 pp.

Kim, K. and S. Ventura, 1993. Large-scale modeling of urban nonpoint source pollution using a geographic information system. *Photogrammetric Engineering and Remote Sensing*, 59(10):1539-1544.

Lo, C.P. and W.E. Noble, 1990. Detailed urban land-use and land-cover mapping using large format camera photographs: an evaluation. *Photogrammetric Engineering and Remote Sensing*, 56(2):197-206.

Lyon, J.G. and R.G. Greene, 1992. Use of aerial photographs to measure the historical areal extent of Lake Erie coastal wetlands. *Photogrammetric Engineering and Remote Sensing*, 58(9):1355-1360.

MacConnell, W.F., 1975. Remote Sensing 20 years of change in Massachusetts: 1952-1972. Mass. Agric. Exp. Sta. Bulletin 630, Amherst, Mass., 79 pp.

Marsh, S.E., J.L. Welsh and C.F. Hutchinson, 1990. Development of an agricultural land-use GIS for surveyed derived from multispatial video and photographic data. *Photogrammetric Engineering and Remote Sensing*, 56(3):359-363.

McCarthy, J., C.E. Olson and J.A. Witter, 1982. Evaluation of spruce-fir forests using small-format photographs. *Photogrammetric Engineering & Remote Sensing*, 48(5):771-778.

Niedzwiedz, W.R., 1990. Assessing permit compliance in residential areas using color 35mm aerial photography. *Photogrammetric Engineering & Remote Sensing*, 56(2):211-224.

Niedzwiedz, W.R. and S.S. Batie, 1984. An assessment of urban development into coastal wetlands using historical aerial photography: a case study. *Environmental Management*, 8(3):205-214.

Norton, D.J., J. Organ and T. Litwin, 1985. Covertype classification and mapping on Long Island's National Wildlife Refuge. *Proceedings of the ACSM-ASPRS Annual Convention*, Washington, D.C., Vol. 2, pp. 585-594.

Paine, D.P. and R.J. McCadden, 1988. Simplified forest inventory using large-scale 70mm photography and tariff tables. *Photogrammetric Engineering & Remote Sensing*, 54(10):1423-1427.

Roberts, A. and L. Griswold, 1986. Practical photogrammetry from 35mm aerial photography. *Photogrammetric Engineering & Remote Sensing*, 52(4):501-508.

Scarpace, F.L., B.K. Quirk, R.W. Kiefer and S.L. Wynn, 1981. Wetland mapping from digitized aerial photography. *Photogrammetric Engineering and Remote Sensing*, 47(6):829-838.

Scherz, J.P. and J.F. Van Domelsen, 1973. Lake Superior Water Quality Near Duluth from Analysis of Aerial Photos and ERTS Imagery, *Remote Sensing and Water Resources Management, American Water Resources Association*, Proceedings, No. 17.

Shafer, R. and S. Degler, 1986. 35mm photography: an inexpensive remote sensing tool. *Photogrammetric Engineering & Remote Sensing*, 52(6):833-837.

Smith, J.T., ed., 1968. Manual of Color Aerial Photography. American Society of Photogrammetry, Falls Church, VA., 550 pp.

U.S. Army Corps of Engineers, 1978. Monthly Bulletin of Lake Levels for the Great Lakes. April. Dept. of the Army, Detroit, MI. pp.4

U.S. Army Corps of Engineers, 1992. Monthly Bulletin of Lake Levels for the Great Lakes. May. Dept. of the Army, Detroit, MI. pp.4

Walker, J.W., 1985. Ultra-light reconnaissance, another tool. *Proceedings of the ACSM-ASPRS Annual Convention*, Washington, D.C., Vol. 1, pp. 371-380.

Welch, R., T.R. Jordan and S.S. Fung, 1985. Photogrammetry: A revolutionary solution to the assessment of ephemeral gully erosion. *Proceedings of the ACSM-ASPRS Annual Convention*, Washington, D.C., Vol. 2, pp. 873-874.

Welch, R., M. Remillard and J. Alberts, 1992. Integration of GPS, remote sensing and GIS techniques for coastal resource management. *Photogrammetric Engineering and Remote Sensing*, 58(11):1571-1578.

APPENDIX

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

County Summary Data Sheet

Year: 1978
County: Milwaukee
Coastal Civil Jurisdiction included in summary (in alphabetical order).

Village of Bayside
City of Cudahy
Village of Fox Point
City of Milwaukee
City of Oak Creek
City of St. Francis
Village of Shorewood
City of South Milwaukee
Village of Whitefish Bay

LAND USE CATEGORIES

	# of structures	Area Acres	Area Hectares
11 Residential			
111 Res. units	12	16	7
garages	1		
sheds	1		
112 Res. units	2	2	1
garages			
sheds			
113 Res. units	2363	847	343
garages	989		
sheds	163		
barns			
115 Res. units			
garages			
sheds			
Subtotal	3531	866	351
12 Commercial			
121 Central Business Dist	9	41	16
122 Shopping Center/Mall			
124 Neighborhood Business Dist	10	4	2
126 Institutional	28	59	24
Subtotal	47	104	42
13 Industrial			
138 Industrial Park	141	238	96

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation	3	32	13
143 Water Transportation			
143.1 Private Marina	2	2	1
143.2 Public Boat Landing	11	41	16
144 Highways		114	46
145 Communications	1	1	<1
146 Utilities	42	129	52
147 Sewage Treatment Plant	21	121	49
148 Landfill		49	20
Subtotal	80	489	198
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field		157	64
182 AG Agriculture Active		79	32
183 F Forest		292	118
184 H Heath			
185 OW Open Water		8	3
186 RL Rock Ledge			
187 SL Slump Zone		134	54
188 WT Wetland		7	3
Subtotal		677	274
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots		50	20
193 Outdoor Recreation	58	849	344
194 Cemeteries			
Subtotal	58	899	364
Total Acres			3272
Total Hectares			1325

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	37264	11361
196 Revetments	40079	12219
197 Groins	# of Groins 19	
198 Dock Non-Flow-Through	# of Docks 10	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

County Summary Data Sheet

Year: 1992
County: Milwaukee
Coastal Civil Jurisdiction included in summary (in alphabetical order).

Village of Bayside
City of Cudahy
Village of Fox Point
City of Milwaukee
City of Oak Creek
City of St. Francis
Village of Shorewood
City of South Milwaukee
Village of Whitefish Bay

LAND USE CATEGORIES

	# of structures	Area Acres	Hectares
11 Residential			
111 Res. units	1	6	2
garages			
sheds			
112 Res. units	3	3	1
garages			
sheds			
113 Res. units	2301	800	324
garages	1131		
sheds	145		
barns			
115 Res. units			
garages			
sheds			
Subtotal	3581	808	327
12 Commercial			
121 Central Business Dist	4	16	6
122 Shopping Center/Mall			
124 Neighborhood Business Dist	19	10	4
126 Institutional	41	108	44
Subtotal	64	134	54
13 Industrial			
138 Industrial Park	137	155	63

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation	1	30	12
143 Water Transportation			
143.1 Private Marina	2	19	8
143.2 Public Boat Landing	11	41	17
144 Highways		80	32
145 Communications	2	<1	<1
146 Utilities	7	25	10
147 Sewage Treatment Plant	99	187	76
148 Landfill		40	16
Subtotal	122	422	171
17 Extractive			
171 Open Pit		29	12
172 Underground			
173 Well			
179 Other Extractive			
Subtotal		29	12
18 Agricultural and Natural			
181 AF Abandoned Field		187	76
182 AG Agriculture Active	3	38	16
183 F Forest	3	351	142
184 H Heath		1	1
185 OW Open Water		43	17
186 RL Rock Ledge			
187 SL Slump Zone		137	56
188 WT Wetland		13	5
Subtotal	6	771	312
19 Open Land, Other			
191 Outdoor-Public Assembly	57	60	24
192 Urban Open Lots	4	55	22
193 Outdoor Recreation	56	856	347
194 Cemeteries		<1	<1
Subtotal	117	972	394
Total Acres		3291	
Total Hectares		1332	

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	42265	12886
196 Revetments	48517	14792
197 Groins	# of Groins 28	
198 Dock Non-Flow-Through	# of Docks 9	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1978
County: Milwaukee
Township, Village or City name: Village of Bayside
PLSS section data sheets included in summary (give full description):

T8N R22E SEC 3
SEC 4
SEC 9
SEC 10

LAND USE CATEGORIES

	# of structures	Area Acres	Area Hectares
11 Residential			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	58	63	26
garages			
sheds	7		
barns			
115 Res. units			
garages			
sheds			
Subtotal	65	63	26
12 Commercial			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional			
Subtotal			
13 Industrial			
138 Industrial Park			

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal			
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field		8	3
182 AG Agriculture Active			
183 F Forest		54	22
184 H Heath			
185 OW Open Water		1	1
186 RL Rock Ledge			
187 SL Slump Zone		2	1
188 WT Wetland		2	1
Subtotal		67	27
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots		1	<1
193 Outdoor Recreation	2	58	23
194 Cemeteries			
Subtotal	2	58	24
Total Acres			189
Total Hectares			76

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls		
196 Revetments	417	127
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1992
County: Milwaukee
Township, Village or City name: Village of Bayside
PLSS section data sheets included in summary (give full description):

T8N R22E SEC 3
SEC 4
SEC 9
SEC 10

LAND USE CATEGORIES

	# of structures	Area Acres	Hectares
11 Residential			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	62	54	22
garages	4		
sheds	2		
barns			
115 Res. units			
garages			
sheds			
Subtotal	68	54	22
12 Commercial			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional			
Subtotal			
13 Industrial			
138 Industrial Park			

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal			
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field		1	1
182 AG Agriculture Active			
183 F Forest		75	30
184 H Heath			
185 OW Open Water		1	1
186 RL Rock Ledge			
187 SL Slump Zone		<1	<1
188 WT Wetland			
Subtotal		78	32
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots			
193 Outdoor Recreation	3	56	23
194 Cemeteries			
Subtotal	3	56	23
Total Acres			187
Total Hectares			76

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	325	99
196 Revetments	1236	377
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks 2	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1978
County: Milwaukee
Township, Village or City name: City of Cudahy
PLSS section data sheets included in summary (give full description):

T6N R22E SEC 23
SEC 24
SEC 25
SEC 36

LAND USE CATEGORIES

	# of structures	Area Acres	Hectares
11 Residential			
111 Res. units	1	5	2
garages	1		
sheds	1		
112 Res. units			
garages			
sheds			
113 Res. units	88	24	10
garages	42		
sheds	6		
barns			
115 Res. units			
garages			
sheds			
Subtotal	139	29	12
12 Commercial			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	3	2	1
126 Institutional	5	12	5
Subtotal	8	14	6
13 Industrial			
138 Industrial Park			

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities		1	<1
147 Sewage Treatment Plant			
148 Landfill			
Subtotal		1	<1
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field		4	2
182 AG Agriculture Active			
183 F Forest		7	3
184 H Heath			
185 OW Open Water			
186 RL Rock Ledge			
187 SL Slump Zone		30	12
188 WT Wetland			
Subtotal		41	17
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots			
193 Outdoor Recreation	6	220	89
194 Cemeteries			
Subtotal	6	220	89

Total Acres	305
Total Hectares	124

Shoreline Modifications		Linear Feet	Meters
195 Sea Walls			
196 Revetments		377	115
197 Groins	# of Groins	11	
198 Dock Non-Flow-Through	# of Docks		

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1992
County: Milwaukee
Township, Village or City name: City of Cudahy
PLSS section data sheets included in summary (give full description):

T6N R22E SEC 23
SEC 24
SEC 25
SEC 36

LAND USE CATEGORIES

	# of structures	Area Acres	Area Hectares
11 Residential			
111 Res. units	1	5	2
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	96	23	9
garages	36		
sheds	9		
barns			
115 Res. units			
garages			
sheds			
Subtotal	142	28	11
12 Commercial			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional	9	13	5
Subtotal	9	13	5
13 Industrial			
138 Industrial Park			

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities	2	1	<1
147 Sewage Treatment Plant			
148 Landfill			
Subtotal	2	1	<1
17 Extractive			
171 Open Pit		1	<1
172 Underground			
173 Well			
179 Other Extractive			
Subtotal		1	<1
18 Agricultural and Natural			
181 AF Abandoned Field			
182 AG Agriculture Active			
183 F Forest			
184 H Heath			
185 OW Open Water			
186 RL Rock Ledge			
187 SL Slump Zone		32	13
188 WT Wetland			
Subtotal		32	13
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots			
193 Outdoor Recreation	12	245	99
194 Cemeteries			
Subtotal	12	245	99
Total Acres			318
Total Hectares			129

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls		
196 Revetments	523	159
197 Groins	# of Groins	13
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1978
County: Milwaukee
Township, Village or City name: Village of Fox Point
PLSS section data sheets included in summary (give full description):

T8N R22E SEC 9
SEC 10
SEC 15
SEC 16
SEC 21

LAND USE CATEGORIES

	# of structures	Area Acres	Hectares
11 Residential			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	279	195	79
garages	35		
sheds	11		
barns			
115 Res. units			
garages			
sheds			
Subtotal	325	195	79
12 Commercial			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional			
Subtotal			
13 Industrial			
138 Industrial Park			

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways		5	2
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal		5	2
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field		<1	<1
182 AG Agriculture Active			
183 F Forest		95	39
184 H Heath			
185 OW Open Water			
186 RL Rock Ledge			
187 SL Slump Zone		8	3
188 WT Wetland			
Subtotal		103	42
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots			
193 Outdoor Recreation		25	10
194 Cemeteries			
Subtotal		25	10
Total Acres			329
Total Hectares			133

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	3612	1101
196 Revetments	2948	899
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks 3	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1992
County: Milwaukee
Township, Village or City name: Village of Fox Point
PLSS section data sheets included in summary (give full description):

T8N R22E SEC 9
SEC 10
SEC 15
SEC 16
SEC 21

LAND USE CATEGORIES

	# of structures	Area Acres	Hectares
11 Residential			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	299	193	78
garages	49		
sheds	21		
barns			
115 Res. units			
garages			
sheds			
Subtotal	369	193	78
12 Commercial			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional			
Subtotal			
13 Industrial			
138 Industrial Park			

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal			
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field		3	1
182 AG Agriculture Active			
183 F Forest	2	87	35
184 H Heath			
185 OW Open Water		<1	<1
186 RL Rock Ledge			
187 SL Slump Zone		5	2
188 WT Wetland			
Subtotal	2	95	38
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots		1	<1
193 Outdoor Recreation	1	22	9
194 Cemeteries		<1	<1
Subtotal	1	23	9
Total Acres			311
Total Hectares			126

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	3304	1007
196 Revetments	7502	2287
197 Groins	# of Groins	5
198 Dock Non-Flow-Through	# of Docks	1

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1978
County: Milwaukee
Township, Village or City name: City of Milwaukee
PLSS section data sheets included in summary (give full description):

T6N R22E	SEC 3	T7N R22E	SEC 10
	SEC 4		SEC 11
	SEC 9		SEC 14
	SEC 10		SEC 15
	SEC 14		SEC 21
	SEC 15		SEC 22
			SEC 27
			SEC 28
			SEC 33

LAND USE CATEGORIES

	# of structures	Area Acres	Area Hectares
11 Residential			
111 Res. units	2	4	2
garages			
sheds			
112 Res. units		1	<1
garages			
sheds			
113 Res. units	736	175	71
garages	441		
sheds	64		
barns			
115 Res. units			
garages			
sheds			
Subtotal	1243	179	73
12 Commercial			
121 Central Business Dist	9	41	16
122 Shopping Center/Mall			
124 Neighborhood Business Dist	4	2	1
126 Institutional	8	13	5
Subtotal	21	55	22
13 Industrial			
138 Industrial Park	105	142	57

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation	3	32	13
143 Water Transportation			
143.1 Private Marina	1	2	1
143.2 Public Boat Landing	8	34	14
144 Highways		91	37
145 Communications	1	1	<1
146 Utilities	3	24	10
147 Sewage Treatment Plant	2	23	9
148 Landfill		49	20
Subtotal	18	255	104
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field		4	2
182 AG Agriculture Active			
183 F Forest		29	12
184 H Heath			
185 OW Open Water			
186 RL Rock Ledge			
187 SL Slump Zone			
188 WT Wetland			
Subtotal		33	13
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots		43	18
193 Outdoor Recreation	32	311	126
194 Cemeteries			
Subtotal	32	354	143
Total Acres			1019
Total Hectares			413

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	24559	7487
196 Revetments	24460	7457
197 Groins	# of Groins 5	
198 Dock Non-Flow-Through	# of Docks 3	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1992
County: Milwaukee
Township, Village or City name: City of Milwaukee
PLSS section data sheets included in summary (give full description):

T6N R22E	SEC 3	T7N R22E SEC 10	SEC 22
	SEC 4	SEC 11	SEC 27
	SEC 9	SEC 14	SEC 28
	SEC 10	SEC 15	SEC 33
	SEC 14	SEC 21	
	SEC 15		

LAND USE CATEGORIES

	# of structures	Area Acres	Area Hectares
11 Residential			
111 Res. units		1	<1
garages			
sheds			
112 Res. units	2	2	1
garages			
sheds			
113 Res. units	742	158	64
garages	482		
sheds	44		
barns			
115 Res. units			
garages			
sheds			
Subtotal	1270	161	65
12 Commercial			
121 Central Business Dist	4	16	6
122 Shopping Center/Mall			
124 Neighborhood Business Dist	11	8	3
126 Institutional	23	50	20
Subtotal	38	74	30
13 Industrial			
138 Industrial Park	112	104	42

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation	1	30	12
143 Water Transportation			
143.1 Private Marina	2	12	5
143.2 Public Boat Landing	10	40	16
144 Highways		72	29
145 Communications	2	<1	<1
146 Utilities	2	23	9
147 Sewage Treatment Plant	22	33	13
148 Landfill		25	10
Subtotal	39	235	95
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field		6	2
182 AG Agriculture Active			
183 F Forest		23	9
184 H Heath			
185 OW Open Water		34	14
186 RL Rock Ledge			
187 SL Slump Zone			
188 WT Wetland		<1	<1
Subtotal		63	26
19 Open Land, Other			
191 Outdoor-Public Assembly	57	60	24
192 Urban Open Lots	1	25	10
193 Outdoor Recreation	21	310	125
194 Cemeteries			
Subtotal	79	394	160

Total Acres	1030
Total Hectares	417

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	29943	9129
196 Revetments	17841	5439
197 Groins	# of Groins 2	
198 Dock Non-Flow-Through	# of Docks 2	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1978
County: Milwaukee
Township, Village or City name: City of Oak Creek
PLSS section data sheets included in summary (give full description):

T5N R22E SEC 13
SEC 24
SEC 25
SEC 36

T5N R23E SEC 31

LAND USE CATEGORIES

	# of structures	Area Acres	Area Hectares
11 Residential			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	1	<1	<1
garages			
sheds			
barns			
115 Res. units			
garages			
sheds			
Subtotal	1	<1	<1
12 Commercial			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional			
Subtotal			
13 Industrial			
138 Industrial Park	28	77	31

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities	10	60	24
147 Sewage Treatment Plant	15	92	37
148 Landfill			
Subtotal	25	152	62
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field		92	37
182 AG Agriculture Active		49	20
183 F Forest		46	18
184 H Heath			
185 OW Open Water		<1	<1
186 RL Rock Ledge			
187 SL Slump Zone		33	13
188 WT Wetland		5	2
Subtotal		225	91
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots		2	1
193 Outdoor Recreation			
194 Cemeteries			
Subtotal		2	1
Total Acres			456
Total Hectares			185

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	3858	1176
196 Revetments	2994	913
197 Groins	# of Groins 2	
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1992
County: Milwaukee
Township, Village or City name: City of Oak Creek
PLSS section data sheets included in summary (give full description):

T5N R22E SEC 13
SEC 24
SEC 25
SEC 36

T5N R23E SEC 31

LAND USE CATEGORIES

	# of structures	Area Acres	Hectares
11 Residential			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units			
garages			
sheds			
barns			
115 Res. units			
garages			
sheds			
Subtotal			
12 Commercial			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional			
Subtotal			
13 Industrial			
138 Industrial Park	14	29	12

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation		<1	<1
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant	65	147	60
148 Landfill		15	6
Subtotal	65	162	66
17 Extractive			
171 Open Pit		2	1
172 Underground			
173 Well			
179 Other Extractive			
Subtotal		2	1
18 Agricultural and Natural			
181 AF Abandoned Field		102	41
182 AG Agriculture Active	3	38	16
183 F Forest		69	28
184 H Heath		1	1
185 OW Open Water		<1	<1
186 RL Rock Ledge			
187 SL Slump Zone		49	20
188 WT Wetland		6	2
Subtotal	3	264	107
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots	1	3	1
193 Outdoor Recreation			
194 Cemeteries			
Subtotal	1	3	1
Total Acres			461
Total Hectares			187

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	5419	1652
196 Revetments	3613	1102
197 Groins	# of Groins	1
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1978
County: Milwaukee
Township, Village or City name: City of St. Francis
PLSS section data sheets included in summary (give full description):

T6N R22E SEC 14
SEC 15
SEC 23
SEC 24

LAND USE CATEGORIES

		# of structures	Area Acres	Hectares
11 Residential				
111	Res. units			
	garages			
	sheds			
112	Res. units	2	2	1
	garages			
	sheds			
113	Res. units	60	15	6
	garages	38		
	sheds	9		
	barns			
115	Res. units			
	garages			
	sheds			
	Subtotal	109	17	7
12 Commercial				
121	Central Business Dist			
122	Shopping Center/Mall			
124	Neighborhood Business Dist	3	1	<1
126	Institutional	13	33	13
	Subtotal	16	34	14
13 Industrial				
138	Industrial Park	3	1	<1

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities	24	41	17
147 Sewage Treatment Plant			
148 Landfill			
Subtotal	24	41	17
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field		29	12
182 AG Agriculture Active		30	12
183 F Forest		5	2
184 H Heath			
185 OW Open Water		6	2
186 RL Rock Ledge			
187 SL Slump Zone		7	3
188 WT Wetland		1	<1
Subtotal		77	31
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots		1	<1
193 Outdoor Recreation	1	39	16
194 Cemeteries			
Subtotal	1	40	16
Total Acres			208
Total Hectares			84

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	61	19
196 Revetments	3234	986
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1992
County: Milwaukee
Township, Village or City name: City of St. Francis
PLSS section data sheets included in summary (give full description):

T6N R22E SEC 14
SEC 15
SEC 23
SEC 24

LAND USE CATEGORIES

	# of structures	Area Acres	Area Hectares
11 Residential			
111 Res. units			
garages			
sheds			
112 Res. units	1	1	1
garages			
sheds			
113 Res. units	39	11	4
garages	45		
sheds	5		
barns			
115 Res. units			
garages			
sheds			
Subtotal	90	12	5
12 Commercial			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	4	1	<1
126 Institutional	8	45	18
Subtotal	12	45	18
13 Industrial			
138 Industrial Park	3	1	<1

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities	3	1	1
147 Sewage Treatment Plant			
148 Landfill			
Subtotal	3	1	1
17 Extractive			
171 Open Pit		26	11
172 Underground			
173 Well			
179 Other Extractive			
Subtotal		26	11
18 Agricultural and Natural			
181 AF Abandoned Field		56	23
182 AG Agriculture Active			
183 F Forest		7	3
184 H Heath			
185 OW Open Water		5	2
186 RL Rock Ledge			
187 SL Slump Zone		2	1
188 WT Wetland		7	3
Subtotal		77	31
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots	2	27	11
193 Outdoor Recreation		27	11
194 Cemeteries			
Subtotal	2	54	22
Total Acres			216
Total Hectares			88

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	48	15
196 Revetments	7052	2150
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1978
County: Milwaukee
Township, Village or City name: Village of Shorewood
PLSS section data sheets included in summary (give full description):

T7N R22E SEC 3
SEC 10

LAND USE CATEGORIES

	# of structures	Area Acres	Hectares
11 Residential			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	291	99	40
garages	103		
sheds	24		
barns			
115 Res. units			
garages			
sheds			
Subtotal	418	99	40
12 Commercial			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional			
Subtotal			
13 Industrial			
138 Industrial Park			

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways		7	3
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal		7	3
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field		1	<1
182 AG Agriculture Active			
183 F Forest		25	10
184 H Heath			
185 OW Open Water			
186 RL Rock Ledge			
187 SL Slump Zone		1	<1
188 WT Wetland			
Subtotal		27	11
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots			
193 Outdoor Recreation	2	5	2
194 Cemeteries			
Subtotal	2	5	2
Total Acres			138
Total Hectares			56

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	1883	574
196 Revetments	402	123
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks 4	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1992
County: Milwaukee
Township, Village or City name: Village of Shorewood
PLSS section data sheets included in summary (give full description):

T7N R22E SEC 3
SEC 10

LAND USE CATEGORIES

		# of structures	Area Acres	Hectares
11 Residential				
111	Res. units			
	garages			
	sheds			
112	Res. units	3	2	1
	garages			
	sheds			
113	Res. units	276	99	40
	garages	137		
	sheds	10		
	barns			
115	Res. units			
	garages			
	sheds			
	Subtotal	426	102	41
12 Commercial				
121	Central Business Dist			
122	Shopping Center/Mall			
124	Neighborhood Business Dist			
126	Institutional			
	Subtotal			
13 Industrial				
138	Industrial Park			

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways		7	3
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal		7	3
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field			
182 AG Agriculture Active			
183 F Forest		35	14
184 H Heath			
185 OW Open Water			
186 RL Rock Ledge			
187 SL Slump Zone		3	1
188 WT Wetland			
Subtotal		38	15
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots			
193 Outdoor Recreation	1	5	2
194 Cemeteries			
Subtotal	1	5	2
Total Acres			151
Total Hectares			61

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	761	232
196 Revetments	1502	458
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks 4	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1978
County: Milwaukee
Township, Village or City name: City of South Milwaukee
PLSS section data sheets included in summary (give full description):

T5N R22E SEC 1
SEC 12
SEC 13

LAND USE CATEGORIES

	# of structures	Area Acres	Area Hectares
11 Residential			
111 Res. units	9	7	3
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	156	44	18
garages	80		
sheds	25		
barns			
115 Res. units			
garages			
sheds			
Subtotal	270	51	21
12 Commercial			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional			
Subtotal			
13 Industrial			
138 Industrial Park	4	17	7

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina	1	<1	<1
143.2 Public Boat Landing	3	6	3
144 Highways			
145 Communications			
146 Utilities	5	3	1
147 Sewage Treatment Plant	4	7	3
148 Landfill			
Subtotal	13	17	7
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field		18	7
182 AG Agriculture Active			
183 F Forest		11	5
184 H Heath			
185 OW Open Water		1	<1
186 RL Rock Ledge			
187 SL Slump Zone		17	7
188 WT Wetland			
Subtotal		47	19
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots		2	1
193 Outdoor Recreation	13	182	74
194 Cemeteries			
Subtotal	13	184	74
		Total Acres	315
		Total Hectares	128

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	1563	477
196 Revetments	2107	642
197 Groins	# of Groins 1	
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1992
County: Milwaukee
Township, Village or City name: City of South Milwaukee
PLSS section data sheets included in summary (give full description):

T5N R22E SEC 1
SEC 12
SEC 13*pLANDYUSE CATEGORIES

		# of structures	Area Acres	Hectares
11 Residential				
111	Res. units			
	garages			
	sheds			
112	Res. units	9	7	3
	garages			
	sheds			
113	Res. units	144	39	16
	garages	76		
	sheds	30		
	barns			
115	Res. units			
	garages			
	sheds			
	Subtotal	259	46	19
12 Commercial				
121	Central Business Dist			
122	Shopping Center/Mall			
124	Neighborhood Business Dist			
126	Institutional			
	Subtotal			
13 Industrial				
138	Industrial Park	8	21	9

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina		7	3
143.2 Public Boat Landing	1	1	1
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant	12	8	3
148 Landfill			
Subtotal	13	16	6
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field		16	7
182 AG Agriculture Active			
183 F Forest	1	13	5
184 H Heath			
185 OW Open Water		2	1
186 RL Rock Ledge			
187 SL Slump Zone		19	8
188 WT Wetland		<1	<1
Subtotal	1	50	20
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots			
193 Outdoor Recreation	16	171	69
194 Cemeteries			
Subtotal	16	171	69
Total Acres			304
Total Hectares			123

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	393	120
196 Revetments	585	178
197 Groins	# of Groins 3	
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1978
County: Milwaukee
Township, Village or City name: Village of Whitefish Bay
PLSS section data sheets included in summary (give full description):

T7N R22E SEC 3
T8N R22E SEC 28
SEC 33
SEC 34

LAND USE CATEGORIES

	# of structures	Area Acres	Hectares
11 Residential			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	694	233	94
garages	250		
sheds	17		
barns			
115 Res. units			
garages			
sheds			
Subtotal	961	233	94
12 Commercial			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional	2	1	1
Subtotal	2	1	1
13 Industrial			
138 Industrial Park	1	1	<1

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways		12	5
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal		12	5
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field			
182 AG Agriculture Active			
183 F Forest		21	9
184 H Heath			
185 OW Open Water			
186 RL Rock Ledge			
187 SL Slump Zone		36	14
188 WT Wetland			
Subtotal		57	23
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots		2	1
193 Outdoor Recreation	2	9	4
194 Cemeteries			
Subtotal	2	11	4
		Total Acres	314
		Total Hectares	127

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	1729	527
196 Revetments	3141	958
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:
1978 - 1992

Civil Jurisdiction
Summary Data Sheet

Year: 1992
County: Milwaukee
Township, Village or City name: Village of Whitefish Bay
PLSS section data sheets included in summary (give full description):

T7N R22E SEC 3
T8N R22E SEC 28
SEC 33
SEC 34

LAND USE CATEGORIES

	# of structures	Area Acres	Hectares
11 Residential			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	643	223	90
garages	302		
sheds	24		
barns			
115 Res. units			
garages			
sheds			
Subtotal	969	223	90
12 Commercial			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	4	1	1
126 Institutional	1	1	<1
Subtotal	5	3	1
13 Industrial			
138 Industrial Park			

	# of structures	Area Acres	Hectares
14 Transportation			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways		1	<1
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal		1	<1
17 Extractive			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			
18 Agricultural and Natural			
181 AF Abandoned Field		3	1
182 AG Agriculture Active			
183 F Forest		43	18
184 H Heath			
185 OW Open Water			
186 RL Rock Ledge			
187 SL Slump Zone		28	11
188 WT Wetland			
Subtotal		74	30
19 Open Land, Other			
191 Outdoor-Public Assembly			
192 Urban Open Lots			
193 Outdoor Recreation		21	9
194 Cemeteries			
Subtotal		21	9
Total Acres			321
Total Hectares			130

Shoreline Modifications	Linear Feet	Meters
195 Sea Walls	2071	632
196 Revetments	8664	2641
197 Groins	# of Groins 4	
198 Dock Non-Flow-Through	# of Docks	